REPORT

ON THE

PROPOSED EXTENSION:

OF THE

Hamilton Water Works,

BY

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AND

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REPORT.

MONTREAL, 10th NOV., 1879.

Thomas Beasley, Esq., City Clerk, Hamilton;

SIR,—We have the honor to report that in compliance with instructions we have examined the present condition of the Hamilton Water Works with a view to insure increased pressure and a greater supply of water.

The disastrous fire of August last has, we find, given rise to discussion from which it would appear that much of the early history of these works has been forgotten. Doubts have been raised as to the propriety of the plan adopted in 1856 and carried out 20 years ago, and schemes which were then considered and disposed of have lately been revived.

As it is of the first importance that in a great municipal work, in which all the ratepayers are stock holders, there should be confidence in the plan, we deem it advisable to recall the early history of the works in order to show that the loss of pressure shown at the fire was forseen; also that all other possible modes with supplying Hamilton with water were carefully considered before the present system was adopted. In the preliminary surveys for these works explorations were made of the creek at Albion Mills, Hess Springs, Ancaster, Dundas, Waterdown Creek and Lake Medad, north-east of Waterdown.

Except the mill streams the others were found worthless on account of their insufficient quantity. Ancaster offered the best prospects, for the reasons given in the following quotation from Mr. Keefer's report of 28th January, 1856.

"The most superficial examination of the Ancaster district reveals conditions very different from those upon the Flamboro' side Instead of the deep and narrow rocky gorges out of which the Dundas and Waterdown streams emerge, those from Ancaster township after falling off the table land flow through well defined valleys of considerable width and with clay banks. From the mountain range to their outlets the streams descend an inclined plane of several miles in extent, having a succession of terraces in its upper portion and affording opportunity for the construction of capacious reservoirs on a retentive soil, whereas upon the Flamboro' side there is a total absence of these features of distance and expansion (at the required elevation) in the embouchure of these streams. Again, the Ancaster streams falling over open terraces instead of through the confined gorges of the opposite side are not shut in, and admit of the easy introduction of auxiliary streams from the west, as well as the facile abstraction of the water from each, in order to conduct it toward the east—a most important feature where as in the present case none of the streams flowing into the bay are capable of affording singly, and at sufficient elevation, the supply required."

Ancaster therefore, was thoroughly surveyed, and was found

capable of affording the supply called for (50,000 inhabitants,) but that for it was not then practicable to determine clearly its probable cost, on account of the necessity for purchasing out the water rights, the cost of which would probably have been fixed by arbitration.

Without this item the cost was nearly as great as that for a pumping scheme, and with it would have been more, but other reasons determined the selection as shown from the report above refered to which says:

"In coming to a decision as to the relative merits of the gravitation or of the pumping system, both of which are practicable, it is important to look forward to the time when the population of Hamilton may exceed 50,000 inhabitants. The examinations made have been based upon the maximum as fixed by my instructions, but when this population is attained the probabilities of its being doubled will be as great as they now are of its being reached. Looking at the commanding position of Hamilton, at the head of the larger navigation of the river St. Lawrence, and at the junction of the main railway routes from the Canadian and American seaboards, and therefore the natural depot for the rich peninsula to the west of it, I see no good reason for limiting its population to 50,000 inhabitants. Before the population reaches 100,000 a larger supply of water will be required than can be afforded by the Ancaster streams, or by any other gravitation sources nearer than the waters which flow into the Grand River. In this case it would be necessary to obtain the required increase of supply either by going to a greater distance or by pumping."

In a further report of the 9th of June, 1856, Mr. Keefer says:

"There is another consideration which weakens any objection to the distance of the Lake from the city, and which gives the lake plan in this respect an advantage over the Ancaster one. As the city increases in population its growth must be eastwead to a greater extent than in any other direction, its extension westward being stopped by the marsh and by the fact that the exporting and importing points by water and by rail will naturally draw the denser population toward the lake. If the city increases as from its position it may fairly be expected to do, it will not be long before the eastern limit reaches Slabtown, the population approaching the reservoir and taking the supply from the descending main already laid. With respect to the Ancaster scheme the interference with private rights, the necessarily irregular condition of the water, the number of separate works required and the risk of accident to each give it no advantages either on the score of economy or efficiency over a supply from the lake, while the strong probability that the ultimate requirements of the city will necessitate a resort to the lake at some future day gives to the latter a decided advantage."

As to more distant sources for a gravitation supply the same report says:

"The distance from which water can be brought in competition with a pumping plan is evidently limited. I did not feel at lib-

erty therefore, notwithstanding the liberal scope of my instructions, to extend the examination to the Grand River or beyond those streams which discharge between Dundas and Burlington Bay canal, until the nearer sources had been tested and found insufficient. The dividing ridge which separates the waters that flow into the Grand River from those discharging into Lake Ontario is between five and six hundred feet above the latter, this summit on the line of the Great Western Railway is in Dumfries, and is 594 feet above Ontario. A supply from the Grand River must be taken from a point on that river at least 600 feet above Ontario, and this elevation cannot be obtained nearer than Galt, a distance of upwards of 30 miles by any feasible route. The cost of any form of conduit for this length would range from £5,000 to £10,000 per mile, and this consideration would render any expenditure for surveys unwarrantable, at least until nearer sources had been condemned."

Assuming the Grand River to afford an ample supply for all future time, the water must have been purchased from those who now have the right to it and outside of this purchase it would have cost more than has been expended upon the present plan to bring it into Hamilton besides the cost of storing and distributing it there.

Lake Erie has been proposed as a source of supply unobjectionable in quality, unfailing in quantity, and as "cheaper than the cost of pumping." A few considerations only are necessary to demonstrate the absurdity of the latter supposition.

To bring a supply for Hamilton from Lake Erie, a pipe or conduit at least 30 inches in diameter and laid upon a grade which would give at least 100 feet of a fall in the distance would be required; if less fall is used the size of the conduit must be increased. The grade line of the pipe, therefore, would be 100 feet below the bottom of the Grand River at Caledonia or the equivalent to this upon any more eastern route.

The summit between Hamilton and Caledonia is 500 feet above Ontario, Lake Erie is 330 feet above Ontario. Add the 100 feet of fall required by the pipe and its level at this point would be 270 feet below the surface.

Tunneling, therefore, would be necessary for the greater part of the distance from Albion Mills to Lake Erie.

The cost would be counted by millions and it would be necessary to assume an annual charge for interest of over $100,000 instead of one of $10,000 per annum in cost of coal.

If Lake Erie water were ever brought to Hamilton by any other method than that of pumping it over the summit (which would require a greater lift than is now given to the water from Lake Ontario), it will be found cheaper to bring it by the route of the Welland Canal than by any other shorter one.

Before the present plan was adopted by the commissioners Mr. Keefer's report was submitted to two eminent hydraulic engineers, John B. Jarvis, Esq., the engineer of the Croton Water Works,

New York, and the late Alfred Craven, Esq., C. E., of that city. They gave their judgment as follows:

"In View of all the circumstances, which it is believed have been fully discussed, the plan of pumping a supply from Lake Ontario as recommended by Mr. Keefer is regarded as the most simple, the most free from unfavorable contingencies, likely to be attended with the least ultimate cost and capable of expansion as the wants of the city may require; it is therefore proposed by the undersigned for adoption."

In the twenty years which have elapsed since these works were completed your population has increased from 18,000 to 35,000, the length of distributing pipe from 13 to 50 miles, the number of water takers from less than 300 to 7,000, and the annual revenue from less than $3,000 to $90,000.

The amount expended upon construction or capital account in the last 18 years has been $305,432,46, of which the filtering basin enlargement has taken $30,149,37, and the high level reservoir $17,757,39, the remainder (over $250,000) upon the extension of the distribution. Nothing has been done toward increasing the pumping power because the limit of that now provided has not yet been reached and because any expenditure in that direction would have been useless without an enlargement of the channel for conveying the increased quantity to the city. The present pumps are capable of affording the weekly supply required without pumping on Sundays, and if at any hour of the week the consumption, as in case of fire, exceeds the hourly delivery of both engines, the reservoir always stands ready to make up the deficiency, but in consequence of the small size of the pumping main the quantity now required cannot be sent forward fast enough or in sufficient volume to prevent a great loss of pressure in the distribution, some portions of which are 3 miles distant from the reservoir and 6 miles from the pumps. The water is withdrawn in the distribution at 7,000 different points (exclusive of hydrants or leaks) and except the hydrants these may be all drawing at once, while it has only a single channel 18 inches in diameter and 3⅓ miles in length from the reservoir to supply all these outlets; if the ends of the pipes nearest the bay were all opened there would be practically no pressure at the Gore, and the reservoir water would not flow out of an opened hydrant there, although it might be rushing past with great velocity to the outlets at the lower points.

This state of things was forseen in 1856. Mr. Keefer's original plan, as shown by his report of January, 1856, proposed a pumping main of 24 inches in diameter to the reservoir, and a supply main from thence of 20 inches in diameter. In May, 1856, the standing committee on fire and water of the City Council called for a reduction of the estimate, and in his report of June, 9th 1856, he replied that in the pumping schemes a considerable reduction could, with great propriety, be made, as his instructions had required him to provide "an ample supply for 50,000 people," but he stated that the first outlay could be restricted "by reducing

the size of the mains, with the view of laying duplicate ones hereafter, when a greate supply would be called for.

The consulting engineers in their report of Dec., 1856, say: They "have arrived at the conclusion to recommend that the plan be based on an average daily supply of 35 gallons and a maximum of 50 gallons per head; at the same time to keep in view such enlargement as your city may desire, when this quantity shall be deemed inadequate to its wants. The average supply for a population of 30,000 on the basis above presented would be 1,050,000 gallons per day, and 1,500,000 gallons for the maximum supply. This is equal to an average of 117 cubic feet, and maximum of 166 cubic feet per minute. To pass this quantity through an 18-inch pipe would require a velocity for the average supply of 1 $\frac{1}{10}$ feet per second, and for the maximum supply of 1 $\frac{6}{10}$ feet per second, and if the velocity be carried to 2 feet per second it would be sufficient for the maximum supply of 40,000 people. This last velocity is rather more than is desirable for the pumping main, but not materially objectionable. It is therefore proposed to put down an 18-inch main pipe which is ample for the present population and will answer the purpose until the population approaches to 40,000, when a second main may be laid, either 18 or 20 inches, as may appear desirable after the experience of the works shall demonstrate what may be necessary. One 18-inch main together with one 20-inch main will discharge the same quantity under equal head as a 24-inch main. The cost of the latter will be about $1.80 per foot less than the the two former, the first cost of the 18-inch pipe will be over $2 per foot less than the 24-inch main. The 18-inch main will be sufficient for probably 12 years or more, and the saving of interest on this difference will more than compensate for the difference in first cost. When it shall become necessary to have the second main this plan will be useful in other respects. In case of repairs on one of the lines of pipes the other will secure the supply in the meantime and an important advantage will be thereby gained at no increase, as has been shown, in the ultimate cost."

In his report of January, 1856, Mr. Keefer had provided an average supply of 50 gallons per head; this has now been reached. The quantity pumped in August last being about 58,000,000 gallons, nearly 14,000,000 gallons per week for a population of 35,000.

Instead of 1,500,000 gallons now being forced daily through the 18-inch main, there are days and weeks in which over 2,000,000 gallons per diem are sent forward. The average supply estimated by the consulting engineers has long since been exceeded, and this has been found to be the experience of almost every other city, in some of which, as shown by the table below, the rate has exceeded 100 gallons per head per diem, at least one half of which is no doubt wasted. The probabilities of future increase in your consumption can best be estimated from the following table:

Population, miles of distributing pipe, number of services and consumption of water in inland cities, United States and Canada. (The consumption in this table is given in wine gallons, which are about one-fifth less than imperial gallons.)

City.	Year	Population.	Miles of Pipe.	No. of Services.	Number of persons per service.	Consumption per mile of Pipe. Gallons.	Consumption per service. Gallons.	Consumption per head. Gallons.
Montreal..	1877	130 000	129 20/100	24 658	5	69 502	364	69
Toronto...		75 000	107 5/10	3 814	19	53 737	1 515	77
Cincinnati		280 000	.....	20 000	14	.....	797	57
St. Louis.		400 000	185	16 800	23	120 808	1 330	56
Cleveland.		136 000	108	7 760	17	71 546	996	56
Detroit ...		110 200	194	18 754	6	59 500	615	105
Chicago...		440 000	425	64 898	7	122 786	803	119
Buffalo		135 000	93 5/10	6 380	21	125 040	1 833	87
Milwaukee		130 000	75 4/10	4 054	32	92 098	1 713	53
Hamilton..	1879	35 000	50	7 000	5	28 000	200	42
Ottawa ...		24 000	40 6/10	5 422	4 1/2	56 676	424	96

The rapid increase of consumption is shown from the fact that the quantity pumped in the 9 months of this year to 1st October, is greater than that in any whole year previous to 1877, being 417,000,000 gallons in 273 days, or over 1,500,000 gallons per day, average equal to the maximum of 50 gallons per head for 30,000 people, as estimated by the consulting engineers.

The quantity pumped was:

1876.....383,800,000 gallons.
1877.....421,729,000 "
1878.....442,195,000 "
1879, (9 months).....416,800,000 "

The quantity pumped in the three summer months has progressed as follows:

1875.....105,000,000 gallons.
1876.....114,000,000 "
1877.....133,000,000 "
1878.....133,000,000 "
1879.....164,000,000 "

The consulting engineers estimated 35 gallons per head, per diem, upon the assumption that a fresh water town would not require as much as those on the salt water. While, however, Boston takes 76 gallons, Brooklyn 63 and Philadelphia 58 per head, Detroit, Chicago, Buffalo, Toronto show that more water is used, or wasted at inland points than at the seaboard. Hamilton in the general use of water as shown by the number of services in proportion to the population as well as in the daily consumption per

head per annum, compares favorably with the above cities. This consumption, however, is the average for the year, but there are days in the year and hours in the day for weeks and months together, when the average is greatly exceeded—perhaps doubled.

On the 1st September, 1879, it is probable that the consumption for at least a couple of hours was at the rate of 3,600,000 gallons per 24 hours, or over 100 gallons per head of the population. On that day no pumping was done, and at 6 o'clock a. m., Sept. 1st, the reservoir level was 21.40; at 6 o'clock p. m., the level was reduced to 18.40, exactly 3 feet in 12 hours. The quantity abstracted in that time was nearly one and a half millions of gallons, the delivery averaging about 120,000 gallons per hour, and to maintain it at that rate, a head of about 45 feet would be required upon the main; in other words, the pressure in the city would be reduced about 45 feet in forcing the water through the main at that uniform rate throughout the day. But there is reason to believe that for two hours or more on that day this loss of head was very greatly exceeded. For two hours in the afternoon it was reported that no water could be obtained on the Dundurn ridge which is 115 feet above Lake level and 70 feet below the full level of the Barton reservoir. There must have, therefore been at this time a loss of head of at least 60 feet and a delivery of the main approaching a rate of 4,000,000 of gallons per 24 hours.

This quantity of water can be obtained through the present main only by submitting to a corresponding loss of pressure. There appears to be an impression that the pressure can be maintained in the city by the pumps. From what has been stated it will be seen that this cannot be done with the reservoir in use. Moreover, without the aid of the reservoir the maximum consumption during certain hours of summer days could not now be maintained as that consumption is greater per hour than the delivery of the pumps.

To maintain the full pressure in the city and at the same time force the maximum consumption of the 1st September last through the present main with the reservoir shut off would require an additional head of 120 feet at the pumps or a total lift of over 300 feet at the engine house. The rapid increase of pressure required to force an increased quantity through the present main, 18 inches diameter and 28,000 feet in length, is as follows;

1,000,000	gallons	per	diem,	head	required	9¾	feet.
2,000,000	"	"	"	"	"	38	"
3,000,000	"	"	"	"	"	88	"
4,000,000	"	"	"	"	"	156	"
5,000,000	"	"	"	"	"	245	"
6,000,000	"	"	"	"	"	345	"

This is the head required to overcome friction alone and is exclusive of the power required to lift the water.

In a very short time the maximum demand for summer days, exclusive of fires, will require double the delivery of the present

pumps, and double the capacity of the single main, so that provision for more water and larger mains has now become imperative.

In adopting the 18-inch main, as was very properly done, it was fully understood at that time that a second or duplicate main would be required in about twelve years (that is in 1872) or when the population "approached" 40,000. Not only, however, has the population reached the point fixed by them when another main would be required, but the consumption per head having largely exceeded the estimate of the consulting engineers, larger capacity in the main becomes imperative even though the population had not reached the figure named by them. The quantity now required for 35.000 is that which they estimated would be sufficient for 50,000 people.

THE FILTERING BASIN.

The capacity of the pumps is not sufficient to test the yield of this basin since its enlargement. But after a week's pumping with both engines at the rate of two and a half million gallons per day, the surface of the basin was drawn down 2 $\frac{6}{10}$ feet below the lake level of the second week of October last.

This would give roughly one million gallons for each foot of filtering head, and as the filtering head is increased this proportion should be increased, but if only maintained, the basin, when drawn down to its full extent, should yield at least six million gallons daily.

Whatever the result may be when by the enlargement of the pumps a test can be made, there is no reason to suppose any further enlargement will be required for years to come. and when such enlargement does become necessary it will be only an extension of the trench along the beach.

The cost of the enlargement added to the original cost of excavation has been but a fraction of what would have been required in order to obtain the water from the lake by any other means; and no other method can approach it in efficiency.

It would be financially impracticable to carry a tunnel, or suction pipe, to a point where the water would be at all times undisturbed by easterly gales and in either case an expensive terminating crib of perishable materials must have been constructed and maintained.

The basin is composed of sand and gravel, which require no repairs, and affords a supply at all times uniform in quality, and of that quality, the highest which it is possible to obtain.

PUMPING POWER.

No additional engine power will be required in order to increase the supply, that power being in excess of the requirements, but as the capacity of the pumps will soon be reached, larger ones should be substituted at the same time that additional capacity is given to the main. The present pumps working constantly can together deliver about 2¾ million gallons per diem, or say, one half more than the average present consumption, and as much as the present main ought to carry. In order to force this quantity through the

main, the pressure at the pumps is 17 lbs. per square inch in excess of that due to the reservoir head ; that is, if there were a stand pipe at the engine house the water would be lifted 40 feet higher than the reservoir level, to obtain head enough to force this quantity through the 18-inch main into the reservoir within the time required. The main is now carrying more than was considered desirable by the consulting engineers, and although the reservoir surface is only 185 feet above Lake Ontario, it is necessary to exert a power equivalent to lifting the water 225 feet above the Lake, in order to obtain a head sufficient to force the delivery of both pumps through the main at the present speed. This extra lift can only be reduced by reducing the speed, and that cannot be done without reducing the quantity.

The present size of the pumps was intended for a greater lift, in the event of a high level reservoir being supplied direct from the Beach. In Mr. Keefer's report of 21st of May, 1857, he states :

" It is proposed now to adopt instead of a 24-inch pumping main and a 20-inch supply pipe a uniform pipe of 18 inches as a pumping main into the city with a view to hereafter having a city reservoir to be supplied directly by the pumps. The Barton reservoir having been moved nearer the city than at first proposed, to shorten the mains, the character of the ground and the position of the Dover Railway caused the adoption of a reservoir level 25 feet lower than was desired, but the pumps were not enlarged on account of the reduced size of the pumping main recommended by the consulting engineers."

The engines are therefore capable of lifting their present delivery to a greater height or, which is the same thing, a larger quantity to the present height, and it is because they have not been exerting their full power and have been worked with a low steam pressure that they have not shown that economy in coal which they otherwise would have done. This surplus power now renders additional engines and engine house accommodation unnecessary, and by the enlargement of the pumps and the substitution of stronger boilers for the present ones in order to use higher steam, the present engines and engine house should be capable of supplying the city's wants for many years to come.

RESERVOIRS.

The Barton reservoir level if placed at the head of John or James streets is sufficiently high to give a fairly effective fire pressure from hydrants on the Gore, but not for the Dundurn ridge.

Its level, 185 feet above Ontario, or 116 feet above the Gore, is that of James street, a little above Mr. McLaren's house.

Until the increased consumption produced the present loss of head the Barton reservoir supplied for domestic purposes all but a few houses under the mountain. The downward tendency of the level in the city pipes which is unavoidable without a city reservoir or mains of excessive size. has drawn the water away from so many residences that it has forced the construction of a high

level reservoir for their domestic supply only, and which therefore makes no provision for fires.

Looking to the fact that the whole of the Dundurn ridge and a considerable portion of the city above Main street, have never had sufficient pressure for fire purposes, and that increased consumption and increased draught will make it more and more desirable to have the means of increasing the fire pressure as well as of maintaining the domestic pressure on the remainder or commercial portions of the city, we think it desirable that there should be a reservoir within the city sufficiently high for fire purposes over the Dundurn ridge. This would enable it to supply the greater number of the houses now attached to the high service in consequence of the falling away of the water from the high levels, thus reducing the number to be supplied by the high level pump to a minimum, as well as reducing the lift of the pump. It would moreover be an addition to the storage which ought to accompany increased size of pumps and mains and place this storage where it would be available in case of accidents to the mains. A city distributing reservoir, if only two-thirds the size of the Barton one, placed in a central position and at an elevation not less than 210 feet above lake level would be an invaluable addition to your works as the only certain method of preventing that loss of pressure, which is now felt, which will be diminished but not removed by the additional main, and which will certainly be repeated in the future when the consumption again taxes the increased delivery.

The consulting engineers, in their report of 1856, say "a second reservoir will be desirable to increase the storage, and to render the distribution more effective, but this is not indispensible and may be deferred with propriety, until the water is let in and experience demonstrates its usefulness." They also added, "excepting as the growth of the city will require further outlay for distribution, the works may be regarded as sufficient for your wants until your population exceeds 35,000.

In determining the extent to which the capacity of the mains must be increased without a city distributing reservoir, two chief conditions are to be fulfilled—the restoration of the pressure in the city to the greatest extent practicable, and provision for increased consumption. This provision must apply not to the average annual consumption, but to the maximum of the hottest summer day.

The gauging of the pressure, which we have made every half hour at hydrants during the night and day in different parts of the city, reveals the ebb and flow of the hydraulic pulse, and shows what must be familiar to most consumers, that from midnight until 5 o'clock of the morning there is still sufficient capacity in the main: but during the day when consumption is greatest, the water is drawn away from the high levels to the middle and lower ones, which latter obtain the whole supply though with a reduced pressure.

The section of the additional main between the engine house and Brethour's is worked under different conditions from that between the city and the reservoir. The pumps working at a uniform rate send forward a regular supply every hour, which cannot be increased, although by a reduction of speed it may be diminished. If this supply from the pumps is greater than the momentary requirements of the city the surplus goes into the reservoir, but if, as is now the case in certain hours of a summer day, it is less, the reservoir supplies the deficiency. The reservoir, therefore, in these hours of greatest drafts, performs the office of a third engine stationed at Brethour's, and it is evident that to meet the varying conditions of the city's consumption, and especially to check the rapidly increasing loss of pressure, greater capacity in the main is required on the city side of Brethour's than beyond that point The figures already given show that while the consumption for the first nine months of 1879 was an average of 1,544,000 gallons per day, it was for three summer months of the same year 1,820,000 gallons per day, and for the whole month of August it averaged nearly 2,000,000 per day. In a 12-hour test in day time on 1st September last, the consumption was found to average 120,000 gallons per hour, or at the rate of 2,880,000 gallons per day of 24 hours, and for two hours of that day, during which the water was entirely off the Dundurn ridge, the consuuption must have reached at least 165,000 gallons per hour, or at the rate of 3,960,000 gallons per day if continuous. On the 29th August last, when the water carts were not at work, the heaviest draft was 144,000 gallons per hour.

From the foregoing we are forced to the conclusion that the hourly draft during the busy portions of many days of the past summer must have averaged 155,000 gallons. The consumption as shown by the annexed table has doubled since 1870, and we do not think it improbable that it will double again in the next ten years; and therefore a maximum hourly rate for summer months, equals to 310,000 gallons, should be provided for.

In order to deliver this quantity so as to maintain a fire pressure of only 82 feet on the Gore and a domestic one of only 35 feet on the Dundurn ridge, the size of the new main between Brethour's and the city must be 24-inches,and with both these mains there must be a working head of 33 feet; in other words, notwithstanding the large size of the second main a loss of head or pressure to that extent must be submitted to in the city. The difference in cost between an 18-inch and a 24-inch would be about $2 per foot, or $29,600 for this distance. If the additional main were made large enough to afford the required supply with a loss of head of only 15 feet the extra cost will be greater than that of a central city reservoir, which later would both extinguish the loss of head present and future, and secure what the Barton reservoir and new mains, no matter how large can never do, a fire pressure over the Dundurn ridge.

The loss of head due to friction in the pipes between Brethour's and the city cannot be entirely overcome by an enlargment of

mains, because this loss of head must increase with the growth of consumption in the city. The uniform steady supply of the pumps will meet all requirements of the average consumption of the 24 hours, but not always those of excessive draught, hence the necessity for a reservoir. Again, when the Barton reservoir is called upon to supplement the deficient supply of the pumps it can only hurry its stored sulplus into the city at a sacrifice of pressure in proportion to the velocity, and, therefore, increasing with the growth of the deficiency. As the loss of head is entirely a question of distance and is proportional to it, the remedy is to transfer the office now performed by the Barton reservoir to a central city one, and take advantage of the opportunity to increase the elevation so as to secure a fire pressure over the Dundurn ridge and an improvement of that now existing over all points of the city below that ridge. This will involve a slight increase in the consumption of coal, but will be well worth it in securing simplicity and certainty of action as compared with the high level reservoir to be turned on only during fires. Under such circumstances the Barton reservoir would be shut off and held as a storage reservoir in cases of emergency and for a distributing reservoir to the eastern district in the future.

It will not be necessary to extend both the mains to the city reservoir, but for fire purposes the branch connecting the former with the latter should not be less than 21 inches.

THE ESTIMATE.

As there are several sites for a central city reservoir, the selection of which will be governed by the cost of and the advantages offered by the ground for such purpose, we have put down a round sum for construction only which may probably be reduced when the site is selected and the plans determined upon. The total cost exclusive of land purchase, foots up to $175,000, as follows:—

New pumps and boilers and connections (for present pumping engines)	$	14 000
Duplication of pumping main, 18-inch diameter from engine house to Queen street, *via* Brethour's, corner King, James and Main streets, 31,550 feet, at $3 per foot		94 650
Valves, valve chambers and special castings on do		2 700
Branch main to city reservoir, 21 inches diameter, say 3,500 feet, at $4 per foot		14 000
Valve chambers and special castings		1 000
New central reservoir in city, say		40 000
	$	166 350
Contingencies, superintendence, etc		8 650
	$	175 000

(Signed) THOS. C. KEEFER,
JOHN KENNEDY.